CARBON DIOXIDE-RICH FLUID INCLUSIONS IN GRANULITE XENOLITHS FROM BAKONY-BALATON HIGHLAND VOLCANIC FIELD, HUNGARY

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We have studied fluid inclusions (over 60 measurements were carried out) in mafic granulite xenoliths from several localities of the Pliocene Bakony-Balaton Highland Volcanic Field, W-Hungary (Szentbékálla, Mindszentkálla, Sabar-hegy, Szigliget, Bondoró-hegy).

Granulite xenoliths are found in basaltic tuffs or in massive alkaline basaltic lavas of the region. The granulites are microgranular and consist of clinopyroxene, feldspar, garnet, orthopyroxene, some amphibole, apatite, and rutile. Grain size varies between a few-hundred micrometers and several millimeters. Feldspars are often as large as several millimeters in diameter, subhedral, and anhedral with curved grain boundaries. Garnet appears quite often with wide reaction corona, consisting of Al-rich orthopyroxene, anorthite-rich plagioclase, and spinel. Orthopyroxene is usually dark green to light brown in color with strong pleochroism. Grains are usually subhedral and show relatively even connecting surfaces, sometimes triple junctions were observed.

Geochemical study of the mafic granulites (Embey-Isztin et al., 2003) show that the protoliths had primitive mafic to slightly tholeitic composition which resemble to mid-oceanic ridge basaltic composition. This chemical features are rare in lower crustal xenolith suites.

Fluid inclusion (FI) petrography

We have found one-phase and two-phase, primary and secondary FI. They occur in clinopyroxene, feldspar and garnet grains. Amphibole grains also contain FI, but they are too small to measure. Some silicate melt inclusions were also observed in plagioclase and in clinopyroxene. Primary inclusions occur as solitary ones or in small groups or clusters mostly in plagioclase or garnet, subordinately in clinopyroxene. Unfortunately, most of the primary, one-phase FI are decrepitated, indicated by decrepitation linear zone of very small inclusions around the fluid inclusions (Fig. 1a). One phase primary FI are usually isometric or slightly oval (Fig. 1a, 1b). Size of fluid inclusions range between a few microns and 50 microns.

Secondary fluid inclusions are mostly two-phase inclusions occurring mainly in clinopyroxene, subordinately in plagioclase occurring in intergranular or intragranular healed fractures, and are often associated with silicate melt inclusions.

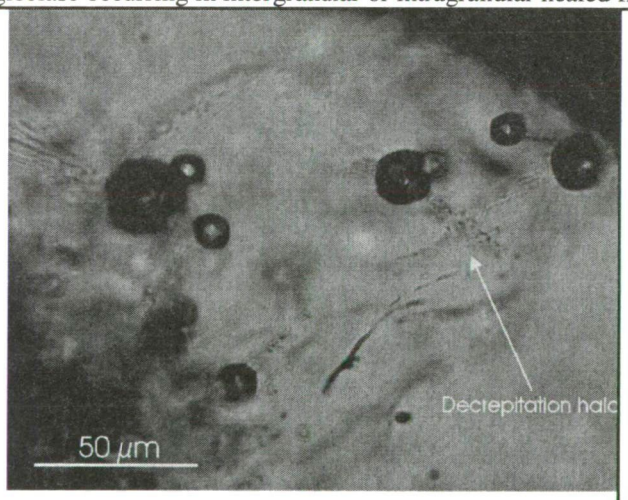

Fig. 1a. Primary inclusions, some with decrepitation fractures in plagioclase

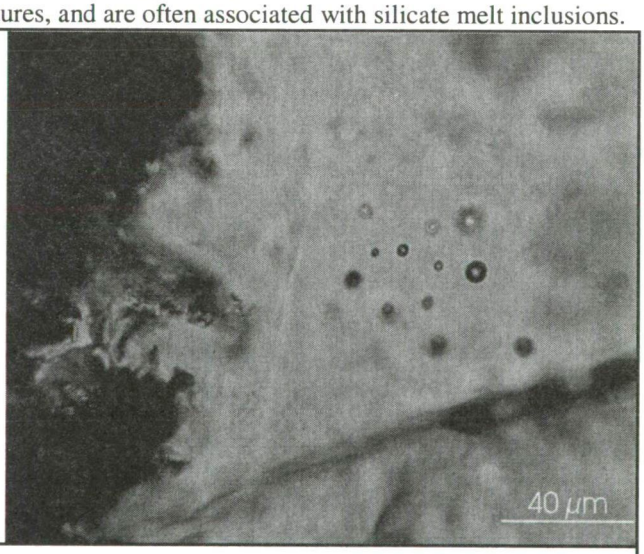

Fig. 1b. Near isometric fluid inclusions in plagioclase

Geothermo-barometry

Garnet-clinopyroxene thermometry of Ellis and Green (1979) and Krogh (1988) show 1010-1073°C at 1.0 GPa pressure and 1032-1094°C at 1.5 GPa pressure for garnet bearing granulites. The estimated temperature for the orthopyroxene-clinopyroxene bearing granulites is 983-1022°C on the basis of two-pyroxene thermometer of Wood and Banno (1973).

Embey-Isztin et al. (1990) suggest similar temperatures, 932-968°C for two-pyroxene granulites and 1035-1051°C and 1.1 GPa for garnet granulites from Szigliget and Szentbékálla and in a recent publication (Embey-Isztin et al., 2003) even lower temperature (800-950°C) at 1200-1500 MPa pressure for xenoliths in Mindszentkálla and Sabar-hegy.

Fluid inclusion study

The microthermometric measurements were made with a USGS heating-freezing stage calibrated with fluid inclusions of known composition. Freezing data show significant decrease of freezing points, which range from -62.3 to -59.0°C. This indicates that other gas species such as N_2 and/or CH_4 and/or CO also occur in the inclusions besides carbon dioxide. This is also indicated by the initial melting temperature (-63°C) of the solid CO_2. Homogenization temperatures of primary inclusions range from +1.9 to -11.0°C. Secondary fluid inclusions in all samples contain predominantly CO_2, which is shown by the slight depression of melting points (between -56.6 and -58.5°C). However, in some cases where the decrease was the most significant, initial melting was also observed between -64 and -62°C. These data imply the presence of additional gas component(s) (possibly N_2, CH_4 or CO). All secondary CO_2 inclusions homogenized into liquid phase between -0.8 and +9.4°C in the samples.

Summary

Geothermo-barometry indicates depth of origin of about 35-52 km for the garnet granulites is (Embey et al., 2003). Primary FIs indicate much shallower maximum depth at about 18-20 km. This discrepancy between the two depth data may have caused by stretching/decrepitation and reequilibration of primary FIs at higher crustal levels. Secondary CO_2-rich inclusions indicate similar depth of trapping. Al-bearing orthopyroxene, and Ca-rich plagioclase+spinel symplectites around garnets indicate temperature increase and pressure decrease (Fig. 2), which occurred before trapping of the xenoliths by the basaltic magma. This pressure decrease coupled with temperature increse may have caused the stretching/decrepitation of primary FIs. The coincidence of depth of reequilibration of primary FIs and depth of trapping of secondary FIs may indicate a temporary rest and fracture formation coupled with migration of CO_2-rich fluids prior to entrainment of lower crustal fragments into the basaltic magma.

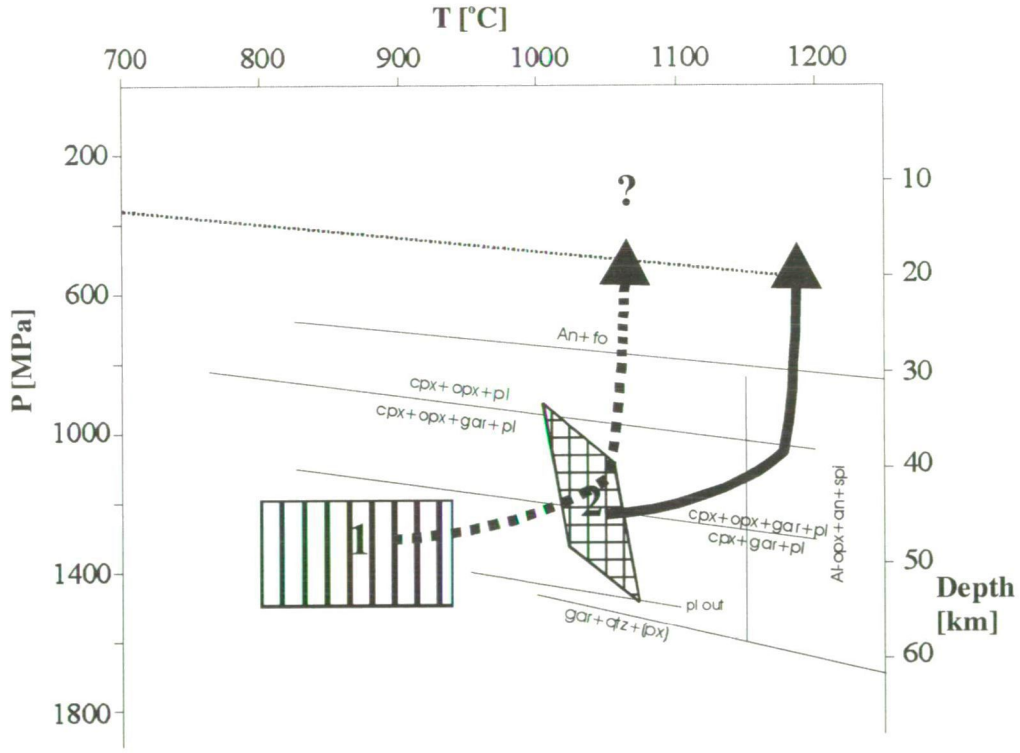

Figure 2. P-T conditions of formation of mafic granulite xenoliths on the basis of geothermo-barometry and mineral equilibria.

Area 1. P-T conditions estimated by Embey-Isztin et al (2003) for xenoliths from Sabar-hegy and Mindszent-kálla.

Area 2. P-T conditions estimated for the Szigliget and Szentbékkálla xenoliths by Embey-Isztin et al (1990), and this study.

The dotted line marks the isochore of the highest density primary inclusion.

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